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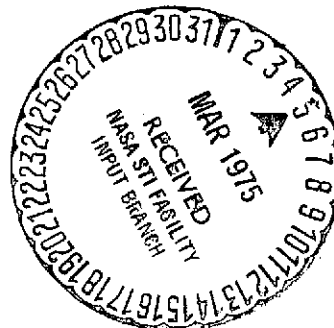
NASA GRANT NGL 19-001-105

INTERPRETATION OF REMOTE SENSING DATA  
IN THE BAYOU LAFOURCHE DELTA OF SOUTH LOUISIANA

Covering the Period:  
February 1974 to February 1975

Submitted By

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## I. INTRODUCTION

In 1971, the Division of Engineering Research, Louisiana State University, received a grant from National Aeronautics and Space Administration entitled "Interpretation of Remote Sensing Data in the Bayou Lafourche Delta of South Louisiana" (NGL 19-001-105). Work under this grant was initiated June 1, 1972, with the assistance of personnel from Nicholls State University. Initial efforts were directed toward a comprehensive "ground truth" program and included the participation of several faculty and staff members, graduate students, and nine undergraduate assistants from LSU and NSU.

At the end of the first eight months a program review was held and specific "Action Oriented Projects (AOP) were defined. These projects were chosen based on the interest shown by state or local agencies, or local private interests. As these projects have been completed, they have been published as Research Monographs, and reviewed by NASA/OUA personnel as well as local authorities.

Several projects were completed in this reporting period. Copies of the reports on these efforts are attached to this report. It should be noted that one AOP, related to the construction of a jetty system at Port Fourchon Louisiana resulted in significant action at the local level. The Corps of Engineers has issued a construction permit for the jetty's, whereas, prior to this study the work was being delayed.

## II. PROGRAM REVIEW 1974-1975

The "Action Oriented Projects" (AOP) initiated in the spring of 1974 are briefly described as follows. The significant results from each project is noted. Copies of Research memorandums or other report forms which give complete results are attached. This program review constitutes our Final Report for this research period.

AOP 5 - The Impact of Transportation Systems (or modes of transportation) on the Marsh Environment.

This project was initiated to study the impact of highway construction in the Lake Boeuf--Des Allemands region. However, due to changes in Louisiana Department of Highways priorities the proposed highways were delayed, and possibly canceled.

Instead of the highway study, we initiated an investigation of the importance of the use of marsh buggies on the marsh environment. A report has been written and copies are attached. A paper has been submitted to the Photogrammetric Journal for possible publication. The results of this study are summarized below. Based on these results, a detailed scientific study of soil densification will be proposed to the Department of Interior, Coastal Zone Management research group.

Color infrared imagery makes it possible to locate these areas which are most seriously damaged by marsh buggy tracks.

With a minimum effort in the field, considerable information regarding extent of use, stage of revegetation or deterioration, water encroachment, etc., can be obtained. This would be practically impossible to accomplish at ground level. The optimum use of buggies, or any other tracked vehicles, in marsh regions, can be enhanced through proper application of aerial imagery.

If the use of tracked vehicles is to be continued, we recommend that alternate routes be defined in the operating area. This would eliminate, to a large extent, continuous use of the same route and would allow faster revegetation.

These recommendations have been made to the Louisiana Wildlife and Fisheries Commission.

AOP 6 - A Study of Impounded Marsh Areas and Areas Which are Subject to Impoundment

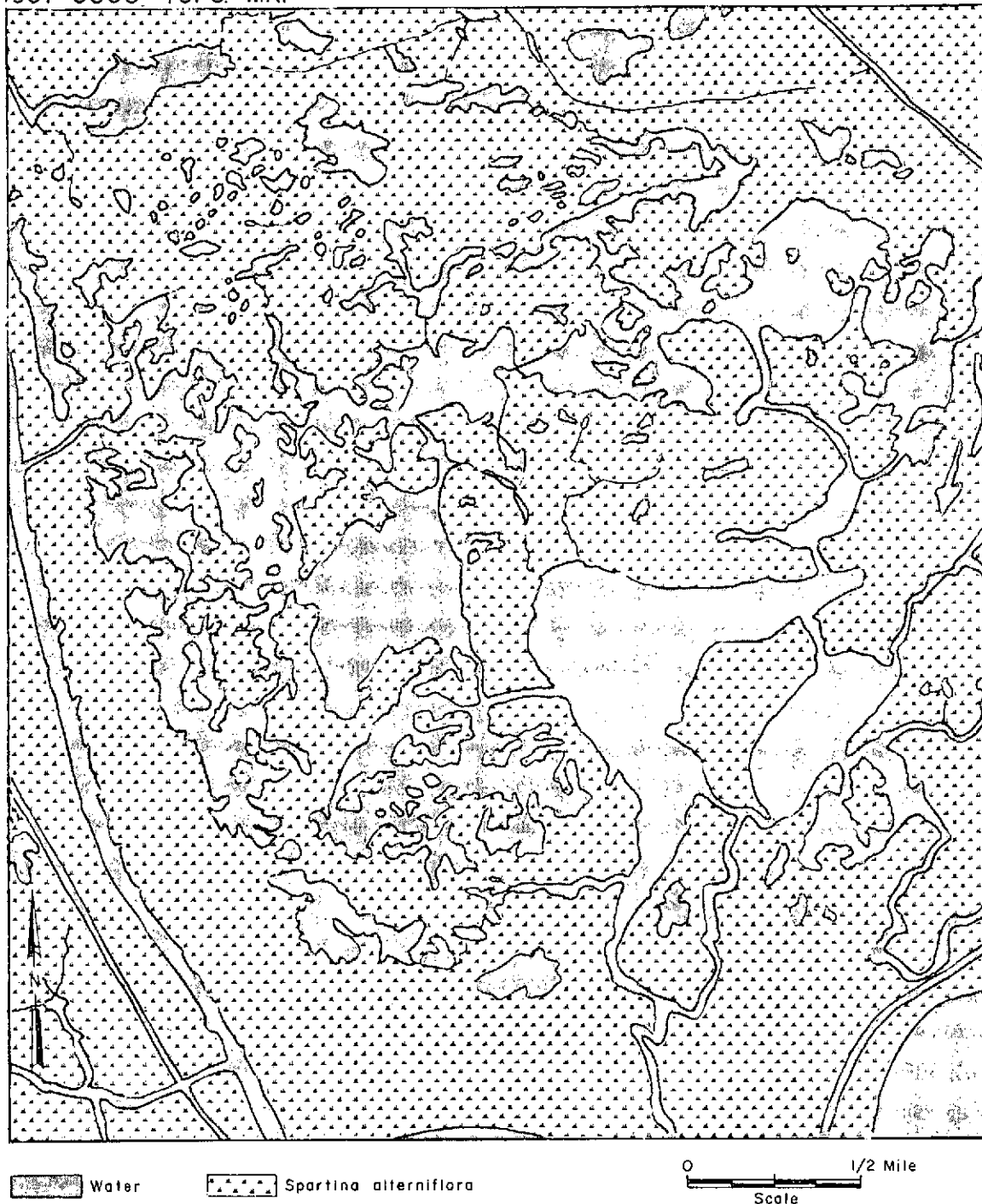
There are certain areas in the Lafourche Delta which are not subject to normal tidal action. Several such areas were chosen for study, and the impounded area located directly north of the Bayou Lafourche fork (Fourchon) between Bayou Lafourche and Bayou Moreau was of particular interest. This is the acreage which has been proposed for possible development by regional interests such as the Port Commission, land developers and others.

In the past, spoil banks have been placed in marsh areas without knowledge of the long-term consequences.

Figure 1 shows the area just north of Port Fourchon (South of Leeville), as it is shown on a 1957 USGS Topographic map. Note the predominate species in *spartina alterniflora*, which is indicative of a saline marsh. Figure 2 shows the same area mapped from color IR photographs taken in 1973. The growth in species varieties characterized the major changes, along with the decrease in *spartina alterniflora*. Table I shows the percentage of coverage by each species; the changes can only be attributed to the impoundment levees which were conducted.

An area does not have to be completely impounded to undergo changes from one type of environment to another. Figure 3 and Table II show the changes in a fresh water marsh southwest of Cutoff, Louisiana.

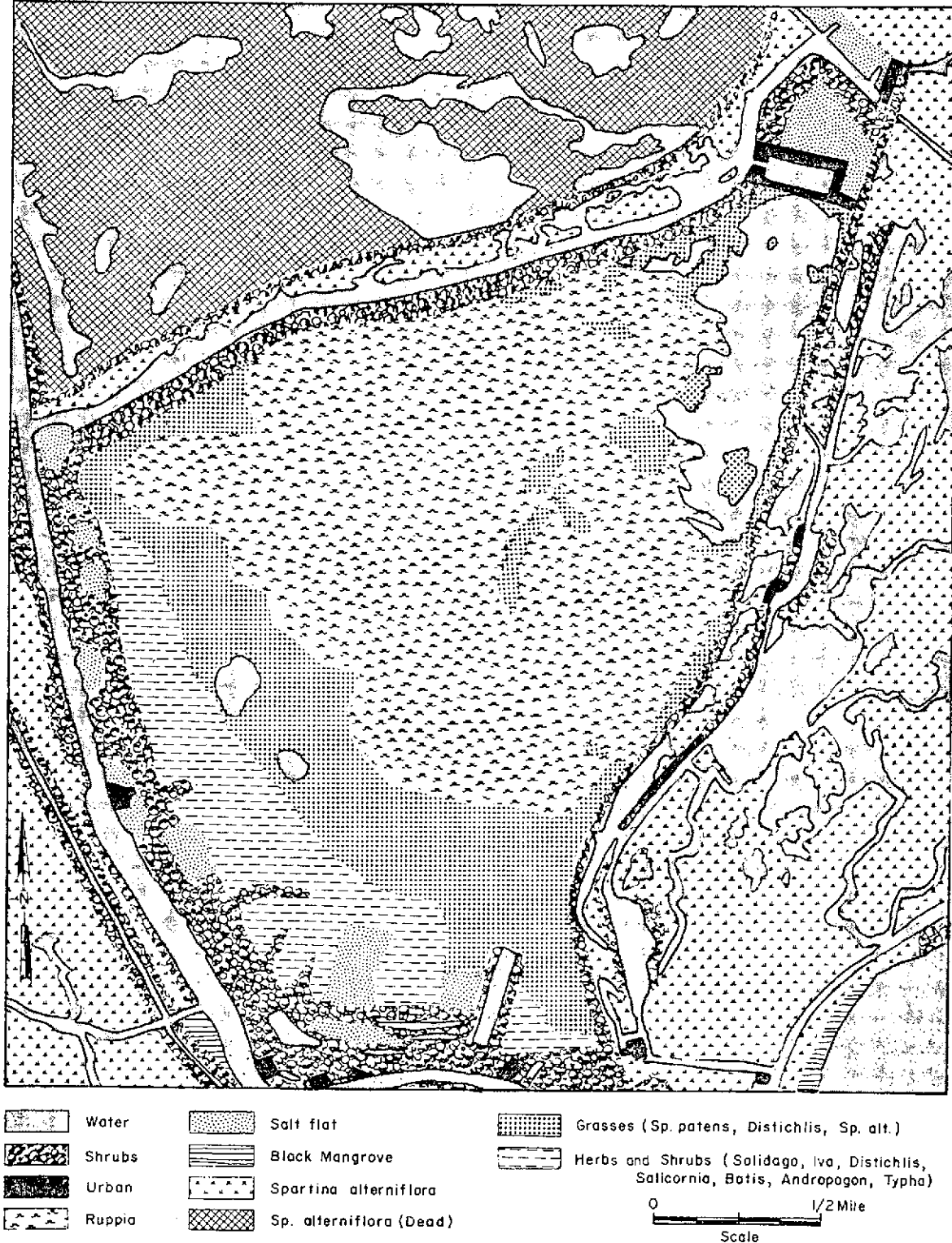
1957 USGS TOPO. MAP



### SALINE MARSH ENVIRONMENT BEFORE IMPOUNDMENT

Figure 1. Area South of Leeville, Louisiana - Bounded by Bayou Lafourche (west), and Bayou Moreau (east)

1973 LOOP COLOR IR PHOTOS



# SALINE MARSH ENVIRONMENT AS AFFECTED BY SPOIL BANKS (IMPOUNDED AREA)

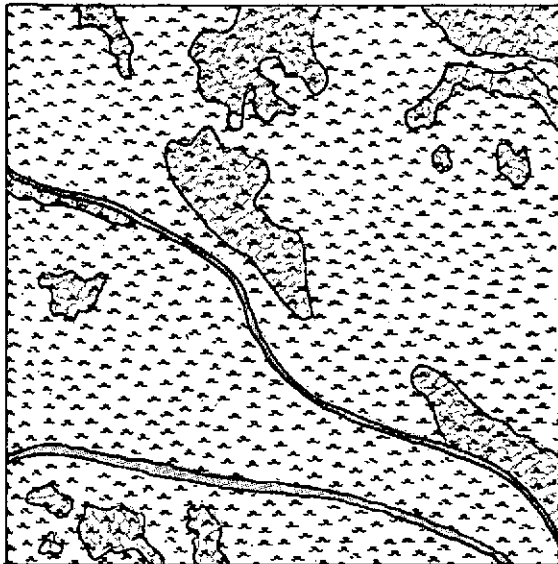
Figure 2. Same area shown in Figure 1.



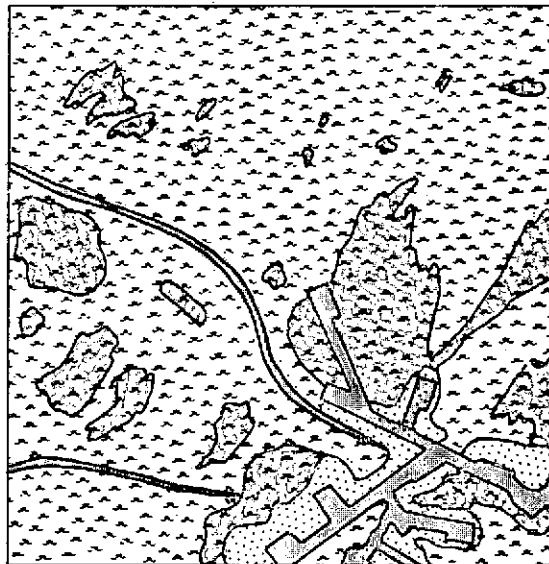
TABLE I - IMPOUNDED AREA  
SALINE MARSH AS AFFECTED BY SPOIL BANKS  
(1967 Impounded)

	<u>1957</u>		<u>1973</u>		<u>Percent</u>	
	<u>Sq. mi.</u>	<u>Percent</u>	<u>Sq. mi.</u>	<u>Percent</u>	<u>Change</u>	
Spaeltern	6.63	71	1.62	18	-53	= change in species
Shrubs	-		0.81	9	+ 9	comp., esp. Ruppia
Grasses	-		0.84	9	+ 9	
Puppia	-		1.96	21	+21	
Salt Flat	-		0.26	3	+ 3	
Herbs & Shrubs	-		0.44	5	+ 5	
Mangrove	-		0.03	<1	+ 1	
Sa.-Dead	-		1.32	14	+14	
Urban	-		0.05	<1	+ 1	
Aquatics	-		1.96	21	+21	= aquatic gain
Land	6.63	71	5.37	58	-13	= land loss
Water	2.70	29	1.91	21	- 8	
Total	9.24		9.24	100		

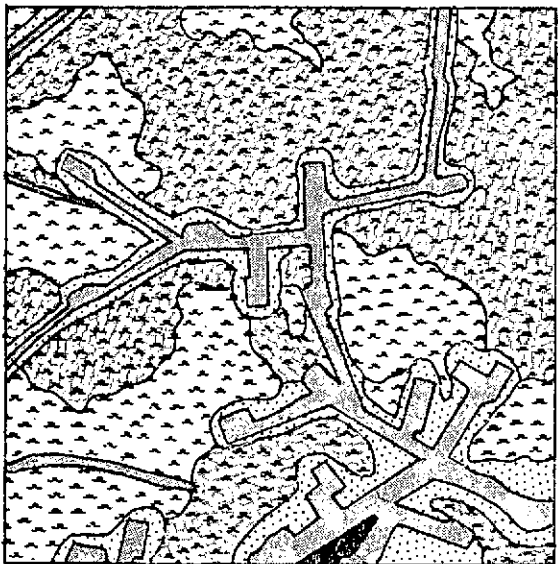
1940 U.S.D.A. B&W PHOTO



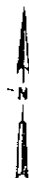
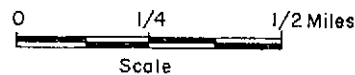
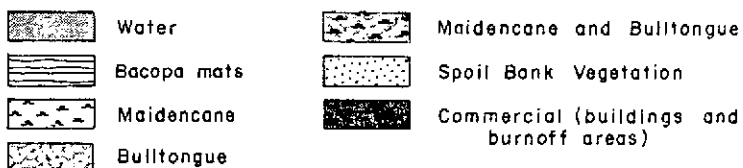
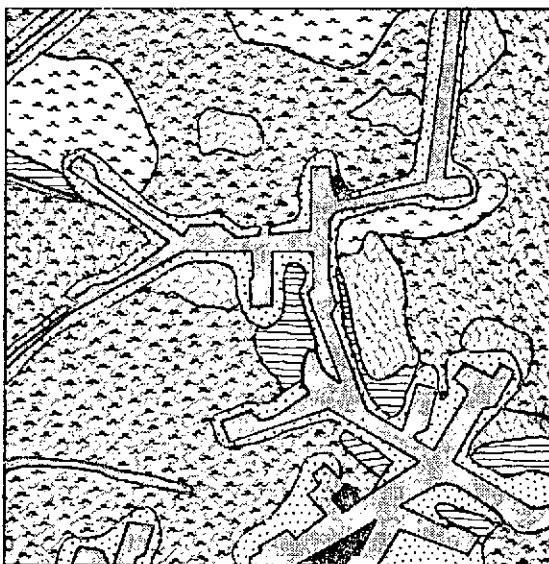
1953 U.S.D.A. B&W PHOTO



1969 USGS B&W PHOTOS



1973 NASA COLOR IR PHOTO FT. 247



### FRESH MARSH ENVIRONMENT AS AFFECTED BY SPOIL BANKS (SEMI-IMPOUNDED AREA)

Figure 3. Changes in A Marsh Area (Bully Camp, West of Bayou Lafourche) due to spoil bank Construction.

TABLE II - SEMI-IMPOUNDED AREA

## FRESH MARSH AS AFFECTED BY SPOIL BANKS

	<u>1940</u>		<u>1973</u>		<u>Percent Change</u>
	<u>Sq. mi.</u>	<u>Percent</u>	<u>Sq. mi.</u>	<u>Percent</u>	
Maidenoane	0.78	78	0.08	8	-70 = change in species
M & B mixture	0.17	17	0.40	40	+23 composition
Bulltonque	-		0.11	11	+11
Bacopa	-		0.04	4	+ 4
Spoil bank veg.	-		0.21	21	+21
Commercial	-		0.01	1	+ 1
Land	0.95	95	0.85	85	-10 = land loss
Nat-Water	0.05	5	0.02	2	- 3
Canals	-		0.13	13	+13 = gain
Total	1.00	100	1.00	100	

Although this area has not been completely surrounded by levees, the changes due to the levee construction (or channel dredging) are significant.

During the summer of 1974 the LSU/Nichols State research team established a ground truth program in some of these areas, especially in the Fourchon impoundment. The location of the four (4) ground truth sites is shown on Figure 4. Sites 3 and 4 are located in open, saline marsh; Site 2 is in a semi-impounded saline marsh, and Site 1 is located in the impoundment under investigation. Our objective was to determine the water quality, salinity, and biological productivity of one environment versus another. The data obtained is shown in Table III. During the fall of 1974, Hurricane Carmen hit this part of the Louisiana coast, and the levees which surrounded this area were breeched in numerous places. In fact, the entire region was subject to flooding from the Gulf of Mexico during the storm and due to the breeching it was subject to normal tidal action for several months after the storm. Figure 4 is a copy of a blown-up portion of one frame from the NASA mission flown immediately after Hurricane Carmen. Point A shows the major breach in the sand bars protecting Bay Champagne, and Points B and C are locations where the levee road was destroyed and the impoundment open to the Gulf. Temporary levees were constructed in the later days of 1974 and the area is again impounded.

From Table III, the most significant factor in the average water quality data is the conductivity at Site 1. It shows that this site is becoming a fresh water reservoir; in fact, the conductivity at Site 2 is considerably below the other sites, showing the semi-impounded nature of this area.

There are no significant differences in the plankton, dredge or trawl data, although Site 4 appears to be a much better area for fish than the



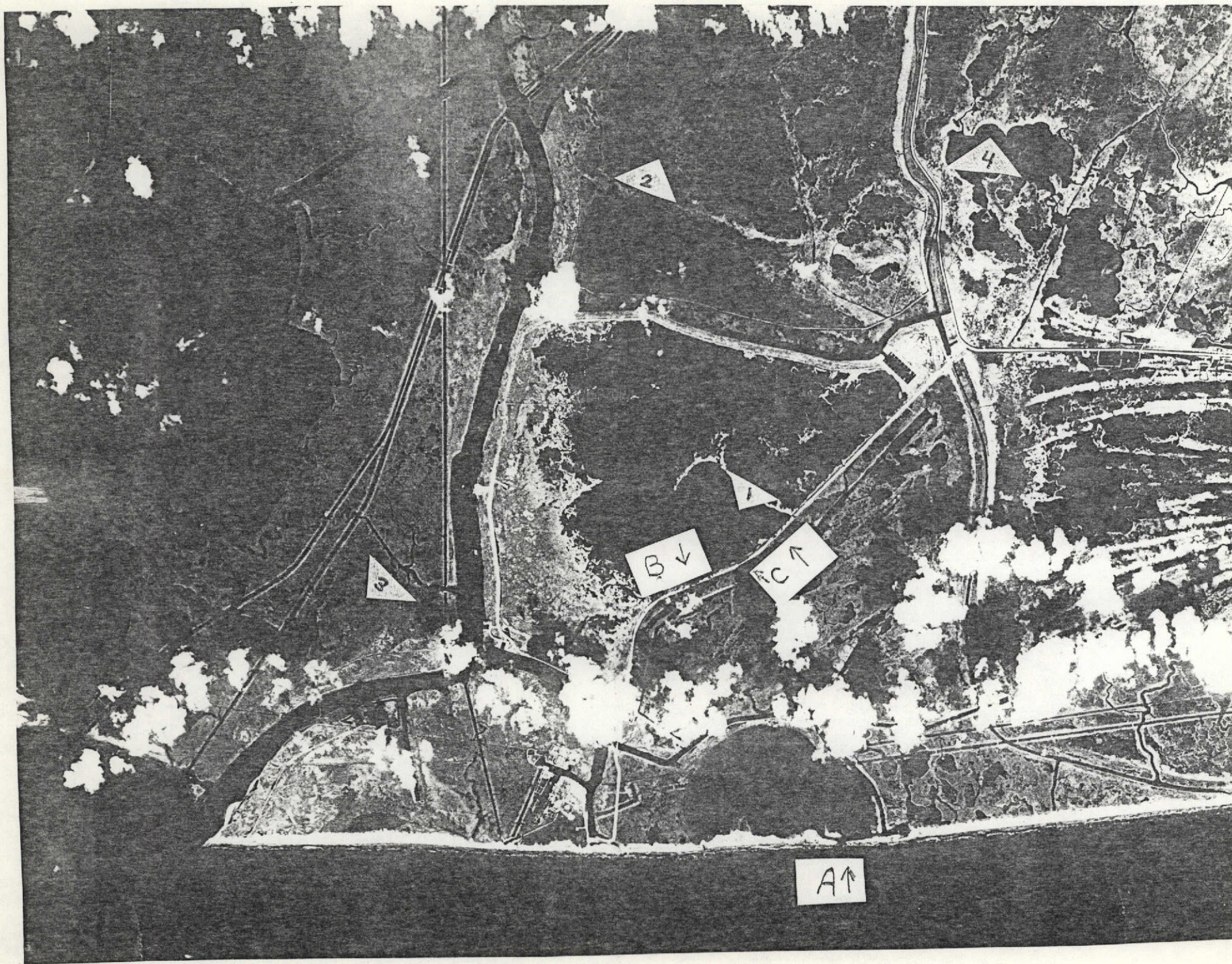


FIGURE 4 - IMPOUNDED AREA AFTER HURRICANE CARMEN - GROUND TRUTH SITES SHOWN



TABLE III

## SUMMARY OF DATA OBTAINED IN SUMMER, 1974

## AT FOURCHON IMPOUNDMENT

## AVERAGED WATER QUALITY DATA

SITE	1	2	3	4
Temp. (°C)	32.1	31.3	31.9	29.6
DO (mg/l)	7.1	6.5	6.4	5.2
COND. (µmho/cm)	678	11380	27,700	18,100
pH	7.52	7.40	7.42	6.58
Turbidity (JTU)	28	34	30	6

## PLANKTON DATA

SITE	DATE	TYPES OF ORGANISMS	TOTAL NO. OBSERVED	TOTAL no./m <sup>3</sup> *
1	6/13/74	1	10	264
1	6/18/74	7	44	1161.6
2	6/12/74	3	16	422
2	6/18/74	13	64	1689.6
3	6/12/74	2	100	2640
3	6/18/74	3	5	132
4	6/13/74	2	2	52.8
4	6/18/74	7	43	1135.2

\*Total no./m<sup>3</sup> = Total no. observed x 26.4

## DREDGE DATA

SITE	DATE	TYPES OF ORGANISMS	TOTAL NO. OBSERVED	TOTAL no./m <sup>2</sup>
1	6/14/74	7	85	1615
1	6/18/74	3	16	304
2	6/13/74	4	14	266
2	6/18/74	4	13	247
3	6/12/74	4	108	2052
3	6/18/74	3	5	95
4	6/12/74	6	22	418
4	6/18/74	3	4	76

\*Total no./m<sup>2</sup> = Total no. observed x 19

# TRAWL DATA

SITE	DATE	TOTAL NO. OF TRAWLED SPECIES	TOTAL WT. (gms.) OF TRAWLED SPECIES	Fish		Invertebrates	
				NO.	WT.	NO.	WT.
1	6/13/74	6	304	6	304	0	0
1	6/18/74	10	382	0	0	10	382
2	6/13/74	71	861	68	849	3	12
2	6/18/74	33	1469	10	127	23	1342
4	6/13/74	8	369	8	369	0	0
4	6/18/74	68	4070	62	4030	6	40

Note: SAMPLE TAKEN BY PULLING 16FT. TRAWL FOR FIVE MINUTES

others. This can be attributed to the low turbidity. The water at Site 3 was very shallow and we did not obtain trawl data at this site.

The Fourchon impoundment has been proposed as a tentative site for on-shore facilities which will support the Louisiana Superport Offshore Oil Port. It has also been suggested by the Lafourche Port Commission that this area be developed as a multi-use port facility. A copy of the Port Fourchon Multiport brochure is attached. Based on the information we have at this time we could not dispute the proposed uses of this area on environmental grounds. The constant hazard from hurricanes was dramatically illustrated during our investigation. Hurricane Carmen upset ten years of man's endeavor in only a ten hour period.

One flight by ERL aircraft was made in November 1974. Data was received in late December and analysis is not complete. We will ask that this area be flown with low altitude aircraft late in 1975 and from the 1974/1975 data, we will define any significant changes to the 1973 condition (Figure 2).

AOP 7 - An Investigation of Environmental Factors Associated With the Current and Proposed Jetty Systems at Belle Pass, Louisiana

This study resulted in a report to the Greater Lafourche Port and Harbor Commission, copies of which are attached. Based to a large degree on the efforts of the LSU research team, the proposed jetty system has been approved. The conclusions and recommendations from this report are given in the following paragraphs.

Comparisons of maps and aerial photographs from 1935 to September 1973 have shown that the existing jetty at Belle Pass has not adversely affected the coastline in the area. Before the construction of the



of the original jetties, the shoreline recession had been estimated by several investigators, who used very old coastal charts, to be between 95 and 150 feet per year.

The Belle Pass area is part of a remnant deltaic plain that has undergone erosion and subsidence during the past 600 or 700 years. At an undefined point east of the jetty, the longshore current, caused by generally southeast waves, changes direction, with flow from east to west toward the jetty and the Timbalier Islands and from west to east toward Grand Isle. Thus the coastline between Belle Pass and Bay Champagne during most of the year is an unreplenished feeder for beach materials in both directions.

The existing jetty and its companion groin apparently have greatly retarded erosion in the area immediately to the east. Between 1945 and 1973, the point of land at the east jetty receded 11 feet (average) per year. Farther east (1000 feet), the recession amounted to 24 feet annually.

West of Belle Pass, the rate was higher. The remnant island receded at a varying rate (38 to 52 feet per year). Farther west, the recession rate apparently becomes evened out to 46 feet per year.

If these average rates for the last 28 years are unquestioned, then it can safely be assumed that the present jetty system has played a major role in the reduced rate of recession at Belle Pass.

Aerial photo interpretation and field observations showed that most eastward flowing littoral material bypasses the jetty and becomes redeposited west of the pass. (One reason for the bypassing may be the inefficient orientation of the jetty with the east shoreline.) At ebb tide, the materials mix with suspended sediment from Bayou Lafourche.

The deposition area varies from 5000 to 8000 feet to the west, depending on ebb or flood tide flow in the channel, and the strength of the littoral current.

Tests on a scale model of the Belle Pass area, with the proposed jetty system in place, indicated that the same bypass conditions would occur. The littoral materials, although deflected farther out by the extended jetty, would be redeposited to the west in the same area as they are now. There is a slight possibility that the proposed east jetty could accumulate some littoral materials, even though the orientation with respect to the shoreline is inefficient for the purpose.

Shoreline erosion west of Belle Pass will continue at the current rate from natural processes. The 1200-ft. dike extension on the proposed west jetty will retard wave action on the remnant island and at the mouth of the north-south canal to the west.

A shoreward extension of the existing east jetty and its companion groin should be included, either as part of the proposed construction or as a separate project. A possible breach of the narrow point, especially during storm waves, would result in serious shoaling of the pass.

The study further indicates that the proposed jetty system will offer a much needed safety factor to navigation in and out of Belle Pass at times of rough seas.

LRP-1 - The Use of Color IR Imagery for a Vegetation Study of Spoil Banks in the Bayou Lafourche Region of South Louisiana

This project was directed at one of the most imposing problems in Louisiana, the environmental impact of dredging and spoil disposal on the state's marsh and swamp lands.

For selected areas, Color IR provides a means of measuring the amount of natural marsh-land which has been converted to open-water

and spoil as a result of dredging and disposal. Also, the imagery is used to recognize the successional stages of the vegetation on the banks. The recognition of stages may provide a valuable tool to those interested in assessing the present state of the spoil banks in Louisiana or other states.

The dates of dredging for 250 canals in this area were obtained from the Corps of Engineers' Permit Branch in New Orleans. These canals were plotted on topographic maps (1:24,000 scale). A chart was derived showing the different environments (boundaries taken from Chabreck's map of Louisiana Coastal Marshes) and the ages of the canals. Based on this chart, the vegetational succession on 1, 2, 3, 4, 5, 10, 15, 20, 25, and 30 year old banks were analyzed.

It is felt that this study provides long-needed information: description of spoil bank vegetation; documented environmental effects of spoil banks on adjacent marshes; estimates of marsh-land loss as a result of dredging and disposal; and a method to determine the vegetational stage of a spoil bank using Color IR imagery. Analyzing the spoil banks which already exist will help us to decide if we wish to create more of these artificial habitats in the form of spoil islands.

The results of this project has been published as the PhD dissertation of Miss Judith Monte, Geography Department, School of Geoscience.

LRP-2 - Erosion and Sediment Transport in the Southwestern Canal, Lafourche Parish, Louisiana

This project has been completed and results published in a Masters Thesis, Department of Geography, and as a Research Memorandum in the Division of Engineering Research. The RM is entitled

"Geomorphic Processes Active in the Southwestern Canal, Lafourche Parish, Louisiana," and has been circulated to all state agencies, local and regional commissions who are interested in marsh management practices. Copies of the RM are attached. The study techniques and conclusions are summarized below.

Field work, laboratory analyses, and interpretation of infrared color imagery were used to provide data for study. The field work was conducted from May to October of 1973 to quantify the rates of erosion and locate areas of deposition. Samples of bank material were analyzed in the laboratory to determine the differences in physical characteristics of three bank types -- natural, shell, and spoil and to relate these differences to the erosion rates.

The erosion rates were determined along the canal for a period of four months at 25 sites representing the three bank types and a variety of environmental conditions. Two plexiglass rods, each 60.0 cm long and 0.93 cm in diameter, were driven horizontally into the bank at each site. As the bank retreated, the exposed lengths of the rods were measured.

The erosion rates were determined from comparison of these measurements, data from a 1954 survey by the Louisiana Department of Public Works, air photos taken in 1953 and 1969, and field measurements made in 1973.

Flow analyses were based on field observations and interpretations of infrared color photographs. The National Aeronautics and Space Administration provided two rolls of infrared color (contact duplicates) made from imagery taken on May 14 and October 25, 1973.

The May imagery (recorded with a Wild RC-8 camera that produced 9" by 9" transparencies at a scale of 1:6000) had sharp detail which was excellent for interpreting the turbidity patterns and bank types.

The October infrared color imagery (also contact duplicates) had a square format (2 1/4" by 2 1/4") and a scale of 1:11500. The smaller scale (70mm film in a Hasselblad) was adequate for the study. An I<sup>2</sup>S camera also recorded black and white multiband imagery (scale, 1:4600) in four spectral ranges: 1) 400-470 nm; 2) 470-580 nm; 3) 580-700 nm; and 4) 720-900 nm.

These remote sensing techniques provided an overall view of distribution patterns that may not be evident at ground level. Infrared color accentuated turbidity patterns and allowed good analyses of the interchange of water between intersecting channels and flow patterns where two water masses meet.

Water samples for determining suspended sediment concentration were collected at six sites during the tropic and equatorial tides for a period of ten weeks. One-half liter samplers were suspended in the water at 0.2 and 0.8 water depth. In the laboratory, each sample was filtered through Millipore filter paper (.47 $\mu$  pores) to determine the weight of sediment.

Destruction of banks by boat wake waves, a major problem in navigation canals, becomes more important in canals subject to tidal influxes. Tidal currents flush sediment from the canal and scour the bottom and sides of the waterway. The cross-sectional area thus increases. An increase in the size of the canal results in a larger tractive force against the wetted perimeter of the channel. It also allows larger and faster vessels to frequent the waterway. As a result, the channel continues to widen and erosion rates increase.

Erosion is the major process occurring in the Southwest Louisiana Canal, with deposition being evident in only two locations. The erosion is self-perpetuating. The continuous decrease in the slope of the canal

banks and the increase in the dispersion of energy is accompanied by an increase in the erosive energy as the tidal prisms increase in size. The ratio of the increase of energy dispersion to the increase of current energy is not known.

Erosion rates measured during this study ranged between .094 and 2.868 cm per day, but these rates also varied according to bank material and location. Such high rates are not unique to the Southwestern Louisiana Canal. Rates equally high or higher have been measured in other canals in the coastal marsh.

The problem of bank destruction in marshland navigation canals is serious but it defies an easy solution. Addition of shell to the banks slows the erosive processes, but does not alleviate the problem. Riprap along the Le Fort Cemetery significantly reduced the rate of widening yet even there widening continues. The effects of bulkheads at the corners of canal junctions were not considered in this study but such construction may be a possible erosion retardant at these locations.

Of the 4572 miles of dredged canals and channels south of the Intracoastal Waterway, about 1000 miles are navigable. Little concern is given to the processes active in these canals. However, widening results in destruction of valuable marshland and estuarine environments. Landowners with property adjacent to canals are constantly losing land. These losses have become a serious legal problem, particularly in large canals such as the Intracoastal Canal, where the right-of-way has already been exceeded.

The knowledge gained concerning the active physical processes in the Southwestern Louisiana Canal are applicable to other waterways in coastal marshes, although the processes which dominate may vary according to location and to the individual characteristics of the waterway.

These processes must be understood along with other natural events because coastal marshes are valuable regions containing renewable resources, such as fish and wildlife, as well as mineral resources. Yet little consideration has been given to the existing problems of canal erosion or to the future prospect of loss of land area.

The study reported here has shown that channel erosion rates progressively increase, with no indications of stabilization. The canals continue to widen until they eventually merge with other waterways and cannot be distinguished from natural water bodies.

#### Other Projects, 1974-1975

Two other projects (not proposed in 1974 proposal) were supported during the year.

First, a project suggested at our last NASA briefing was initiated and completed. The report, entitled "A Comparison of High- and Low-Altitude Aerial Infrared Color Photography For Remote Sensing of Louisiana Coastal Marshlands," which covers this work is attached for reference.

Secondly, the ERTS Satellite imagery was submitted to Dr. Tony Lewis of the Geography Department for use in his Remote Sensing class, Geography 199. A typical undergraduate report which was produced as a class-project is attached. It is entitled: "The Ten Natural Vegetation Regions of Louisiana: An Interpretation Utilizing Imagery from the Earth Resources Technology Satellite."